



## **Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)**

*Forrest G. Hall and Jeffrey A. Newcomer, Editors*

### **Volume 10 BOREAS AFM-6 Boundary Layer Height Data**

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# **BOREAS AFM-6 Boundary Layer Height Data**

James Wilczak

## **Summary**

The BOREAS AFM-6 team from NOAA/ETL operated a 915-MHz wind/Radio Acoustic Sounding System (RASS) profiler system in the SSA near the OJP site. This data set provides boundary layer height information over the site. The data were collected from 21-May-1994 to 20-Sep-1994 and are stored in tabular ASCII files.

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## **1. Data Set Overview**

### **1.1 Data Set Identification**

BOREAS AFM-06 Boundary Layer Height Data

### **1.2 Data Set Introduction**

The data were collected by the BOREal Ecosystem-Atmospheric Study (BOREAS) Airborne Fluxes and Meteorology (AFM)-06 team during 5 months from late spring to summer in 1994. Boundary layer data were measured by the National Oceanic and Atmospheric Administration (NOAA)/Environment Technology Laboratory (ETL) 915-MHz wind/Radio Acoustic Sounding System (RASS) profiler. The data were collected near the Southern Study Area (SSA)-Old Jack Pine (OJP) flux tower.

### **1.3 Objective/Purpose**

The BOREAS field work objectives were to measure continuous hourly profiles of wind velocity and temperature in the atmospheric boundary layer (ABL) and lower troposphere, to measure the depth of the daytime convective boundary layer, and to measure the occurrence of precipitation, all using a 915-MHz radar wind/RASS profiler. The data were then to be used to document average boundary

layer structure, and especially changes in boundary layer structure during the course of the boreal summer growing season.

#### **1.4 Summary of Parameters**

The AFM-06 boundary layer height data include date, time, and boundary layer height.

#### **1.5 Discussion**

NOAA/ETL operated a 915-MHz wind profiling radar and surface meteorological station near the SSA-OJP from 21-May-1994 through 20-Sep-1994. The data provided by the instrumentation are vertical profiles of wind speed and direction and virtual temperature, as well as boundary layer depth ( $Z_i$ ) and the presence of precipitation. These measurements were made with 100-m vertical resolution with the lowest measurement height at 150 m above ground level (AGL). The maximum height sampled was 3,850 m AGL, although on many days the maximum height of the wind measurements was in the range of 2-3 km due to weak signal strength in the region of the lower troposphere above the ABL.

#### **1.6 Related Data Sets**

BOREAS AFM-06 Mean Wind Profile Data

BOREAS AFM-06 Mean Temperature Profile Data

BOREAS AFM-06 Surface Meteorological Data

## **2. Investigator(s)**

### **2.1 Investigator(s) Name and Title**

Robert Banta, Brooks Martner, James Wilczak NOAA Environmental Laboratory

### **2.2 Title of Investigation**

Outer Boundary Layer Effects on Surface Fluxes of Momentum, Heat, Moisture, and Greenhouse Gases from the Boreal Forest

### **2.3 Contact Information**

#### **Contact 1:**

James Wilczak  
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325 Broadway  
Boulder, CO 80303  
(303) 497-6245  
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#### **Contact 2:**

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Raytheon ITSS  
Code 923  
NASA GSFC  
Greenbelt, MD 20771  
(301) 286-7858  
(301) 286-0239 (fax)  
Jeffrey.Newcomer@gsfc.nasa.gov

### **3. Theory of Measurements**

The above measurements were obtained by measuring the zeroth, first, and second moments of the radar Doppler spectrum. The zeroth moment is the signal power. The range-corrected signal power can alternatively be expressed in terms of the turbulence structure parameter CN2. It is well-known that the vertical profile of CN2 exhibits a sharp peak at the midpoint of the inversion transition region, due to local mixing of relatively cool, moist boundary layer air with warmer and dryer air aloft. Our measurements of Zi were obtained from the peak value in the vertical profile of CN2 from a vertically pointing radar beam. The first moment of the Doppler spectrum is the Doppler velocity. The vertical profile of wind velocity was measured by combining the Doppler velocities measured along three radar beams: one vertical, and two oblique beams pointing at elevations of 75 degrees, oriented 90 degrees apart. The vertical profile of virtual temperature was measured using the RASS, in which an array of acoustic speakers surrounds the radar and generates a sound pulse. The radar signal reflects off of this acoustic wave front, and the measured Doppler shift indicates the velocity of the sound pulse, which is proportional to the virtual temperature of the air. The second moment of the Doppler spectrum, or spectral width, can provide a measure of the strength of the turbulence within the boundary layer. The second moment has not been directly used in the present analysis. Finally, the presence of precipitation is determined by using both signal power and the vertical velocity. Rain and snow have much greater signal power than does clear air, and nearly uniform downward velocities. Rain can be distinguished from snow by its greater reflectivity, and by its greater fall velocity. Because of the high sensitivity of the profiler, it is capable of detecting small amounts of rain that might not be measured by a traditional surface rain gauge. The profiler detects only the presence of precipitation, however, and at present cannot give a quantitative measure of rainfall amount.

### **4. Equipment**

#### **4.1 Sensor/Instrument Description**

915-MHz wind profiling radar with RASS.

##### **4.1.1 Collection Environment**

The 915-MHz profiler was used during various ambient weather conditions that occurred at the BOREAS SSA-OJP site.

##### **4.1.2 Source/Platform**

Ground-based.

##### **4.1.3 Source/Platform Mission Objectives**

The ground supported the needed instrumentation.

##### **4.1.4 Key Variables**

Inversion height.

##### **4.1.5 Principles of Operation**

Standard Doppler radar techniques.

##### **4.1.6 Sensor/Instrument Measurement Geometry**

One vertical beam, two oblique beams 15 degrees from vertical at an elevation of 75 degrees.

##### **4.1.7 Manufacturer of Sensor/Instrument**

Wind Profiler: NOAA/ETL (contact: James Wilczak at the address found in Section 2).

## **4.2 Calibration**

### **4.2.1 Specifications**

None given.

#### **4.2.1.1 Tolerance**

None given.

### **4.2.2 Frequency of Calibration**

None given.

### **4.2.3 Other Calibration Information**

None given.

## **5. Data Acquisition Methods**

During the course of 1 hour, the radar makes 18 cycles through each of the three radial beams, averaging for 60 seconds on each beam. These measurements require a total of 54 minutes. Prior to this, the RASS temperature profile is measured on the vertical beam during the first 5 minutes of the hour. During BOREAS, the RASS temperature observations consisted of 15 measurements, each 15 seconds in length. Each of these individual radial measurements of both wind and temperature is then quality controlled through an automated pattern recognition scheme, and then the measurements are combined into a single value of wind and temperature reported for each hour.

## **6. Observations**

### **6.1 Data Notes**

The wind profiler operated unattended for most of the 4-month observation period.

### **6.2 Field Notes**

The wind profiling radar and surface meteorological station were located at a site 1.0 km south and 1.6 km east of the OJP tower flux site. The radar site was in a clearing in the jack pine forest, with fetches (clear distances) of 200 m to the north, 500 m to the south, 150 m to the east, and 1 km to the west. Ground cover within the clearing consisted of grass, brush, and young jack pine trees, approximately 1-2 m tall.

## **7. Data Description**

### **7.1 Spatial Characteristics**

#### **7.1.1 Spatial Coverage**

The North American Datum of 1983 (NAD83) coordinates of the site are:

Lat.        = 53.91 °N  
Long.      = 104.40 °W  
Alt.        = 511 m above sea level

This location is the SSA, 1.0 km south and 1.6 km east of the OJP flux tower.



### **7.1.2 Spatial Coverage Map**

Not available.

### **7.1.3 Spatial Resolution**

Beamwidth = 9.9 degrees (one-way, 3 dB)

Range resolution = 101 m

Range limits = 0.112-3.889 km AGL (38 range gates)

### **7.1.4 Projection**

Not applicable.

### **7.1.5 Grid Description**

Not applicable.

## **7.2 Temporal Characteristics**

### **7.2.1 Temporal Coverage**

Measurements were made from 21-May-1994 through 20-Sep-1994.

### **7.2.2 Temporal Coverage Map**

Not available.

### **7.2.3 Temporal Resolution**

Measurements were made every hour during the period.

## **7.3 Data Characteristics**

### **7.3.1 Parameter/Variable**

The parameters contained in the data files on the CD-ROM are:

Column Name

-----  
SITE\_NAME  
SUB\_SITE  
DATE\_OBS  
TIME\_OBS  
INVERSION\_HT  
PARM\_VALUE\_FLAGS  
CRTFCN\_CODE  
REVISION\_DATE

### 7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
INVERSION_HT	The measured inversion height.
PARM_VALUE_FLAGS	Contains values or codes that indicate special conditions for the data parameters. See data set documentation for descriptions of these codes.
Flag	Description
DR	Height was measured with rain was present during part of the hour.
DV	Height was measured with virga was present during part of the hour.
GC	Height was lost in ground clutter.
MI	Height was not measured
OK	Height was measure without incident.
PD	Height became poorly defined above 500 meters.
RN	Height was not measured due rain.
VI	Height was not measured due to virga.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

### 7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
INVERSION_HT	[kilometers]
PARM_VALUE_FLAGS	[none]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

### 7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by NOAA/ETL]
TIME_OBS	[Supplied by NOAA/ETL]
INVERSION_HT	[Supplied by NOAA/ETL]
PARM_VALUE_FLAGS	[Assigned by BORIS]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

### 7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-OJP-RDR01	SSA-OJP-RDR01	None	None	None	None
SUB_SITE	AFM-06-RDR01	AFM-06-RDR01	None	None	None	None
DATE_OBS	21-MAY-94	20-SEP-94	None	None	None	None
TIME_OBS	0	2300	None	None	None	None
INVERSE_HT	0	3.8	-999	None	None	None
PARM_VALUE_FLAGS	N/A	N/A	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	16-AUG-96	16-AUG-96	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Clctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.

N/A -- Indicates that the value is not applicable to the respective column.

None -- Indicates that no values of that sort were found in the column.

-----

## 7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,INVERSION_HT,PARM_VALUE_FLAGS,CRTFCN_CODE,
REVISION_DATE
'SSA-OJP-RDR01','AFM06-RDR01',21-MAY-94,0,-999.0,'MI','CPI',16-AUG-96
'SSA-OJP-RDR01','AFM06-RDR01',21-MAY-94,100,-999.0,'RN','CPI',16-AUG-96
'SSA-OJP-RDR01','AFM06-RDR01',21-MAY-94,200,-999.0,'RN','CPI',16-AUG-96
'SSA-OJP-RDR01','AFM06-RDR01',21-MAY-94,300,-999.0,'RN','CPI',16-AUG-96
```

## 8. Data Organization

### 8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was the data collected at a given site on a given date.

### 8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

## **9. Data Manipulations**

### **9.1 Formulae**

#### **9.1.1 Derivation Techniques and Algorithms**

None given.

### **9.2 Data Processing Sequence**

#### **9.2.1 Processing Steps**

During the course of 1 hour, the radar makes 18 cycles through each of the three radial beams, averaging for 60 seconds on each beam. These measurements require a total of 54 minutes. Prior to this, the RASS temperature profile is measured on the vertical beam during the first 5 minutes of the hour. During BOREAS, the RASS temperature observations consisted of 15 measurements, each 15 seconds in length. Each of these individual radial measurements of both wind and temperature is then quality controlled through an automated pattern recognition scheme, and then the measurements are combined into a single value of wind and temperature reported for each hour.

#### **9.2.2 Processing Changes**

None given.

### **9.3 Calculations**

#### **9.3.1 Special Corrections/Adjustments**

None given.

#### **9.3.2 Calculated Variables**

None given.

### **9.4 Graphs and Plots**

None given.

## **10. Errors**

### **10.1 Sources of Error**

During spring and autumn seasons, it is possible that the profiler winds can be contaminated by the presence of migrating birds. These errors are now well understood, and can be recognized from large values of signal power, spectral width, and sudden changes in wind speed occurring near sunset and sunrise. Periods of contaminated winds have been hand edited from the data set. Birds do not directly affect RASS temperatures, although they could have a secondary effect by contaminating vertical velocity, which is used to correct RASS temperatures. No corrections for contaminated vertical velocities on RASS have been made.

### **10.2 Quality Assessment**

#### **10.2.1 Data Validation by Source**

See Section 10.2.3.

#### **10.2.2 Confidence Level/Accuracy Judgment**

See Section 10.2.3.

### **10.2.3 Measurement Error for Parameters**

During the first 3 days and last 3 days of operation, ETL personnel were at the site taking balloon intercomparisons. These assessments have shown typical values of agreement of the balloons with profiler, typically 1-2 m/s and 1 deg C. Wind velocity differences between 915-MHz wind profilers and precision research aircraft have been found to be on the order of 0.9 m/s.

### **10.2.4 Additional Quality Assessments**

None given.

### **10.2.5 Data Verification by Data Center**

BORIS personnel verified that the delivered data agreed with the information provided by the AFM-06 team.

## **11. Notes**

### **11.1 Limitations of the Data**

None given.

### **11.2 Known Problems with the Data**

None given.

### **11.3 Usage Guidance**

None given.

### **11.4 Other Relevant Information**

None given.

## **12. Application of the Data Set**

These data could be used in conjunction with the other AFM-06 data sets to get a detailed characterization of the atmosphere above the SSA-OJP site.

## **13. Future Modifications and Plans**

None given.

## **14. Software**

### **14.1 Software Description**

None given.

### **14.2 Software Access**

None given.

## **15. Data Access**

The boundary layer height data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

### **15.1 Contact Information**

For BOREAS data and documentation please contact:

ORNL DAAC User Services  
Oak Ridge National Laboratory  
P.O. Box 2008 MS-6407  
Oak Ridge, TN 37831-6407  
Phone: (423) 241-3952  
Fax: (423) 574-4665  
E-mail: [ornldaac@ornl.gov](mailto:ornldaac@ornl.gov) or [ornl@eos.nasa.gov](mailto:ornl@eos.nasa.gov)

### **15.2 Data Center Identification**

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics  
<http://www-eosdis.ornl.gov/> [Internet Link].

### **15.3 Procedures for Obtaining Data**

Users may obtain data directly through the ORNL DAAC online search and order system [<http://www-eosdis.ornl.gov/>] and the anonymous FTP site [<ftp://www-eosdis.ornl.gov/data/>] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

### **15.4 Data Center Status/Plans**

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

## **16. Output Products and Availability**

### **16.1 Tape Products**

None.

### **16.2 Film Products**

None.

### **16.3 Other Products**

These data are available on the BOREAS CD-ROM series.

## 17. References

### 17.1 Platform/Sensor/Instrument/Data Processing Documentation

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May, P.T. and J.M. Wilczak. 1993. Diurnal and seasonal variations of boundary layer structure observed with a radar wind profiler and RASS. *Mon. Wea. Rev.* 121, 673 682.

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Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. *Bulletin of the American Meteorological Society*. 76(9):1549-1577.

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Whiteman, C.D. and X. Bian. 1994. Semidiurnal solar tides in the mountain atmosphere. *Proc., 23rd Conf. on Alpine Meteorology* (Lindau, Germany), Deutsche Wetterdienst, Offenbach, Germany.

Wilczak, J.M., R.G. Strauch, F.M. Ralph, B.L. Weber, D.A. Merritt, J.R. Jordan, D.E. Wolfe, L.K. Lewis, D.B. Wuertz, J.E. Gaynor, S.A. McLaughlin, R.R. Rogers, A.C. Riddle, and T.S. Dye. 1995. Contamination of wind profiler data by migrating birds: characteristics of corrupted data and potential solutions. *J. Atmos. Ocean. Technol.* 12, 449-467.

### **17.3 Archive/DBMS Usage Documentation**

None.

## **18. Glossary of Terms**

None.

## **19. List of Acronyms**

ABL	- Atmospheric Boundary Layer
AFM	- Airborne Fluxes and Meteorology
AGL	- Above Ground Level
ASCII	- American Standard Code for Information Interchange
BOREAS	- BOREal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk - Read-Only Memory
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
ETL	- Environment Technology Laboratory
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NOAA	- National Oceanic and Atmospheric Administration
NSA	- Northern Study Area
OJP	- Old Jack Pine

ORNL - Oak Ridge National Laboratory  
PANP - Prince Albert National Park  
RASS - Radio Acoustic Sounding System  
SSA - Southern Study Area  
URL - Uniform Resource Locator

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